Advanced Light-Weight On-Orbit Gimbal Structures (ALOGS)

6th Annual Mirror Tech Days Conference

September 19, 2006

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Hardric Laboratories

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Advanced Light-Weight On-Orbit Gimbal Structures (ALOGS)

Background / Summary

- Earlier fabrication methods used "Be Hog-out" approach to produce major gimbal structures
- While technically successful, high cost & long fabrication lead-times will be unacceptable for future generation systems
- SBIR MDA04-132; "Advanced Light-Weight On-Orbit Gimbal Systems" focused on Improving Performance & Manufacturability of Major Gimbal Structures for Future MDA/AF Space Systems
- Phase I results indicate that welded "AlBe" **(AlBeWeld™)** structures can meet the requirements for Future Gimbal Structures with dramatic reductions in both cost & fabrication lead-times

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Program Objectives

- **Phase I Objectives**
  - **Develop lower cost gimbal**
  - **Improve lead time**
  - **Improve manufacturability**
  - **Measure and evaluate EB welding capabilities**
  - **Demonstrate repair techniques and verify structural and thermal integrity of repair**

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Advanced Light-Weight On-Orbit Gimbal Structures (ALOGS)

Be -vs- AlBe Design Considerations

- AlBe is almost equal to "Be" in thermal conductivity with slightly higher CTE (Still ~50% of Al)
- AlBe approaches the lightweight stiffness performance of "Be" with material costs at ~60% of "Be"
- Has capability to weld structural components together which results in dramatic reductions of input material
- AlBe machines like "Al" vs "Be"; Machining Time ~50% that of "Be"
  - Still requires environmental controls for H & S
- Vendor base for machining "AlBe" is larger than "Be"
- **Welded "AlBe" Structures Can Be Repaired in Case of Damage during Assembly & Integration**

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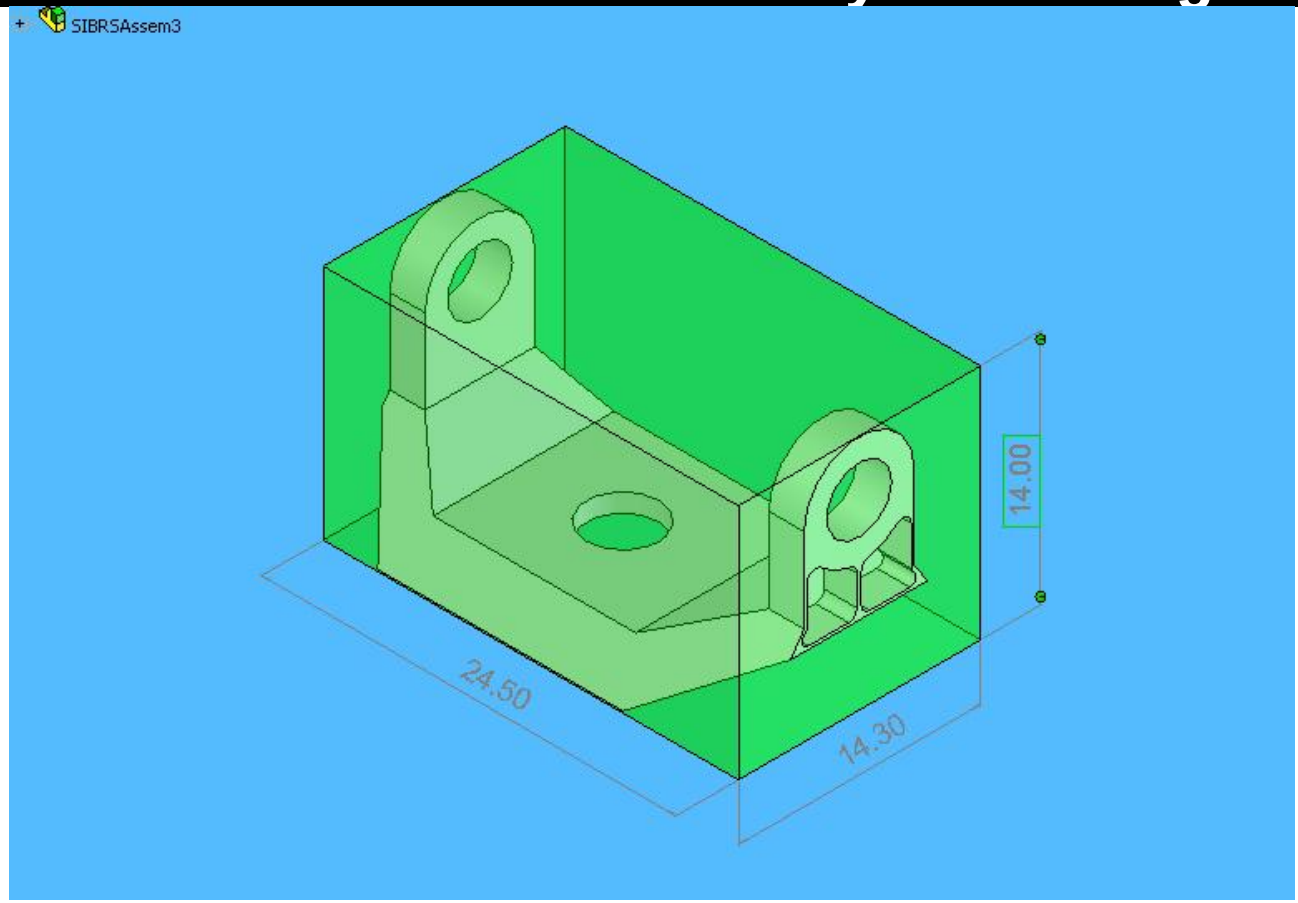
Original "Be Hog-out" Approach Required a Large Block of "Be" with Heavy Machining



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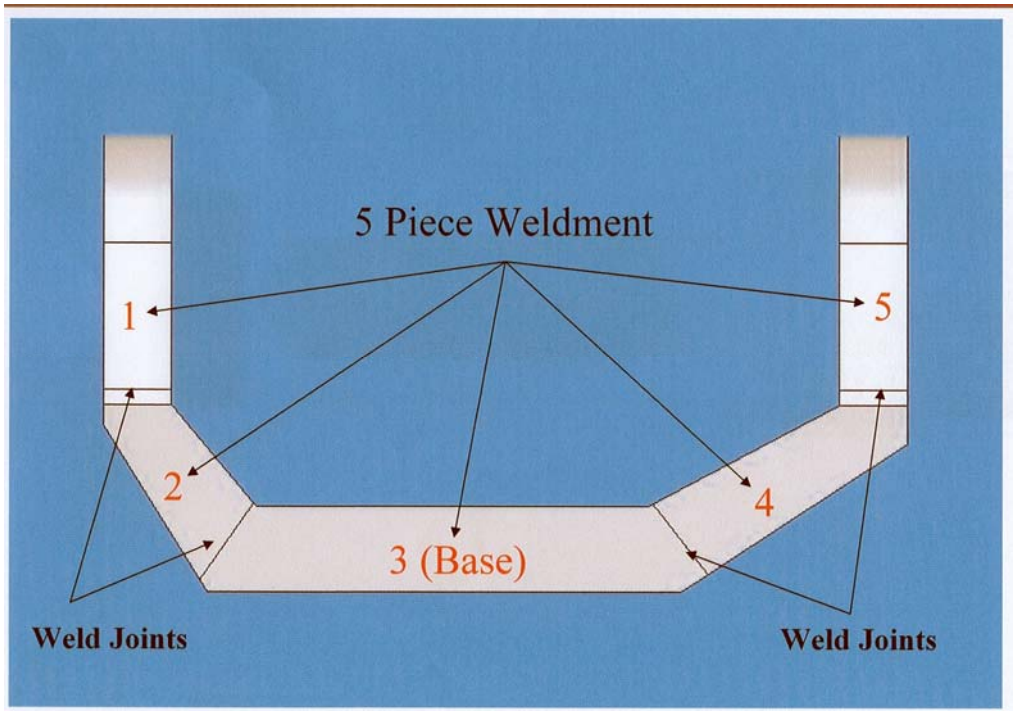
AlBeWeld™ Yoke Design

- **Full Scale Yoke is Five-piece Design**
  - **Used Three piece / Half yoke for Phase I- due to funding**



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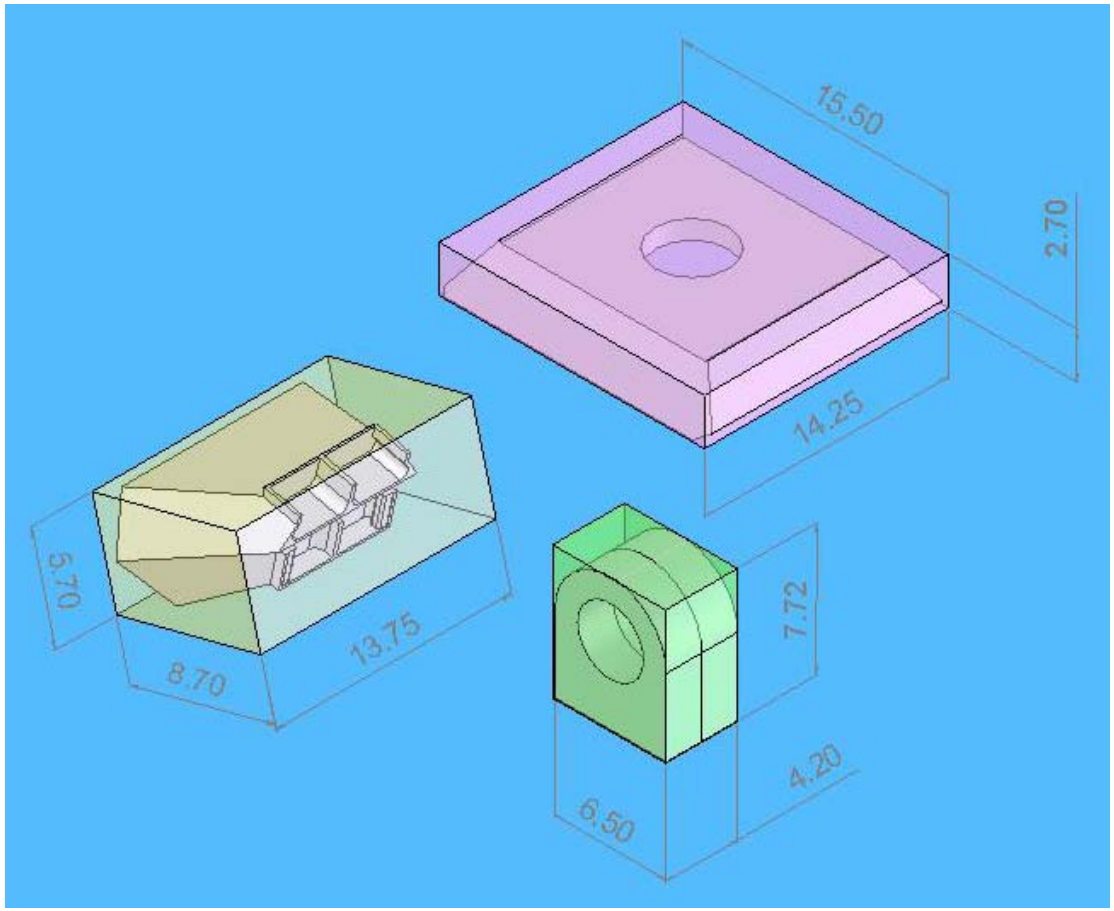
Material Layout- EB Welded Approach



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Input Material Comparison

"Hog-out" Option	"AlBe" Weld Option
One Input Block	**Three Input Blocks**
14.0”x14.3”x24.50”	15.5”x2.7”x14.25”
	7.72”x4.2”x6.5”
	5.7”x8.7”x13.75”
328.6 Lbs of Be	
372.7 Lbs of AlBe	113.1 Lbs of AlBe

"AlBe" Weld Option Provides a 70% Material Reduction

"AlBe" Material ~ 40% Lower Cost / Pound vs "Be"

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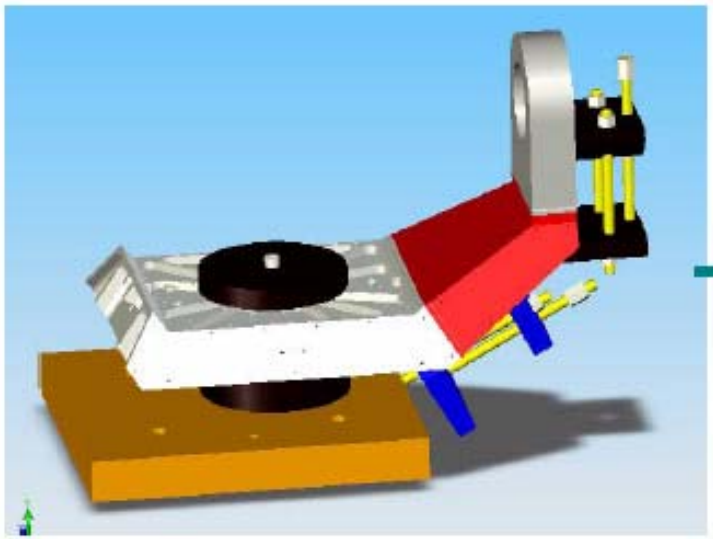
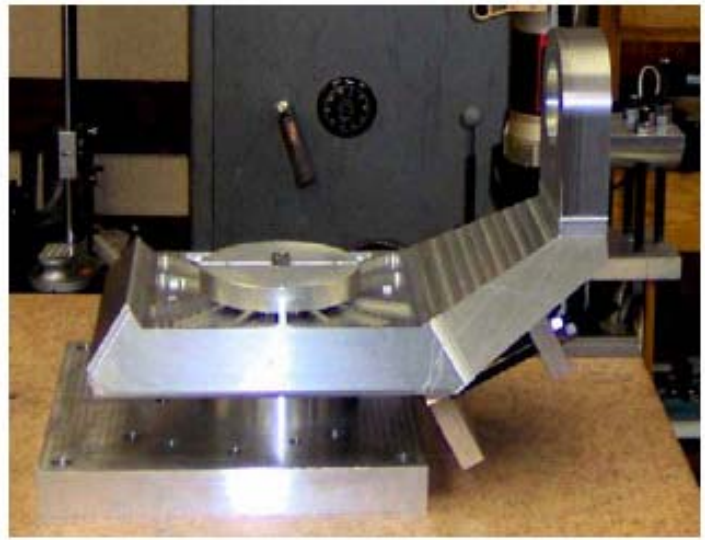
Three Piece EB Welding Fixture



Welding Fixture Design



Welding Fixture

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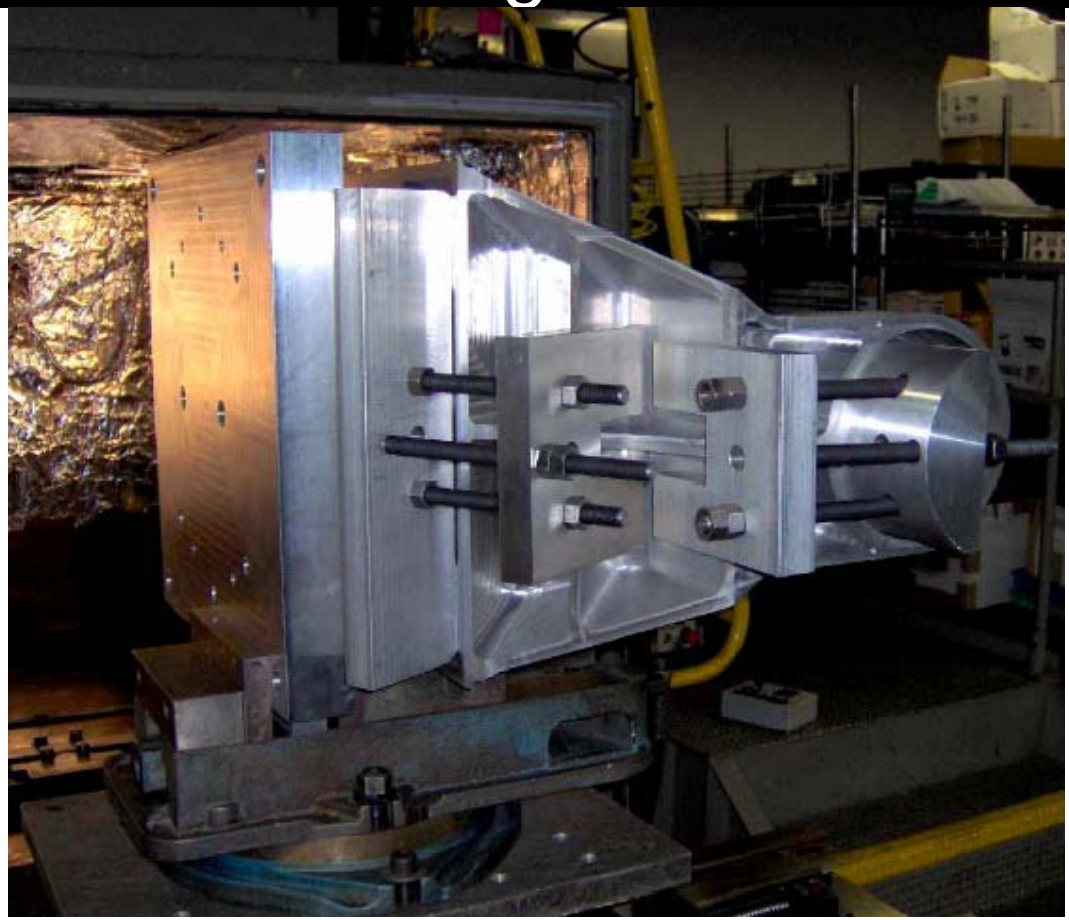
Welding Fixture



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Post Welding

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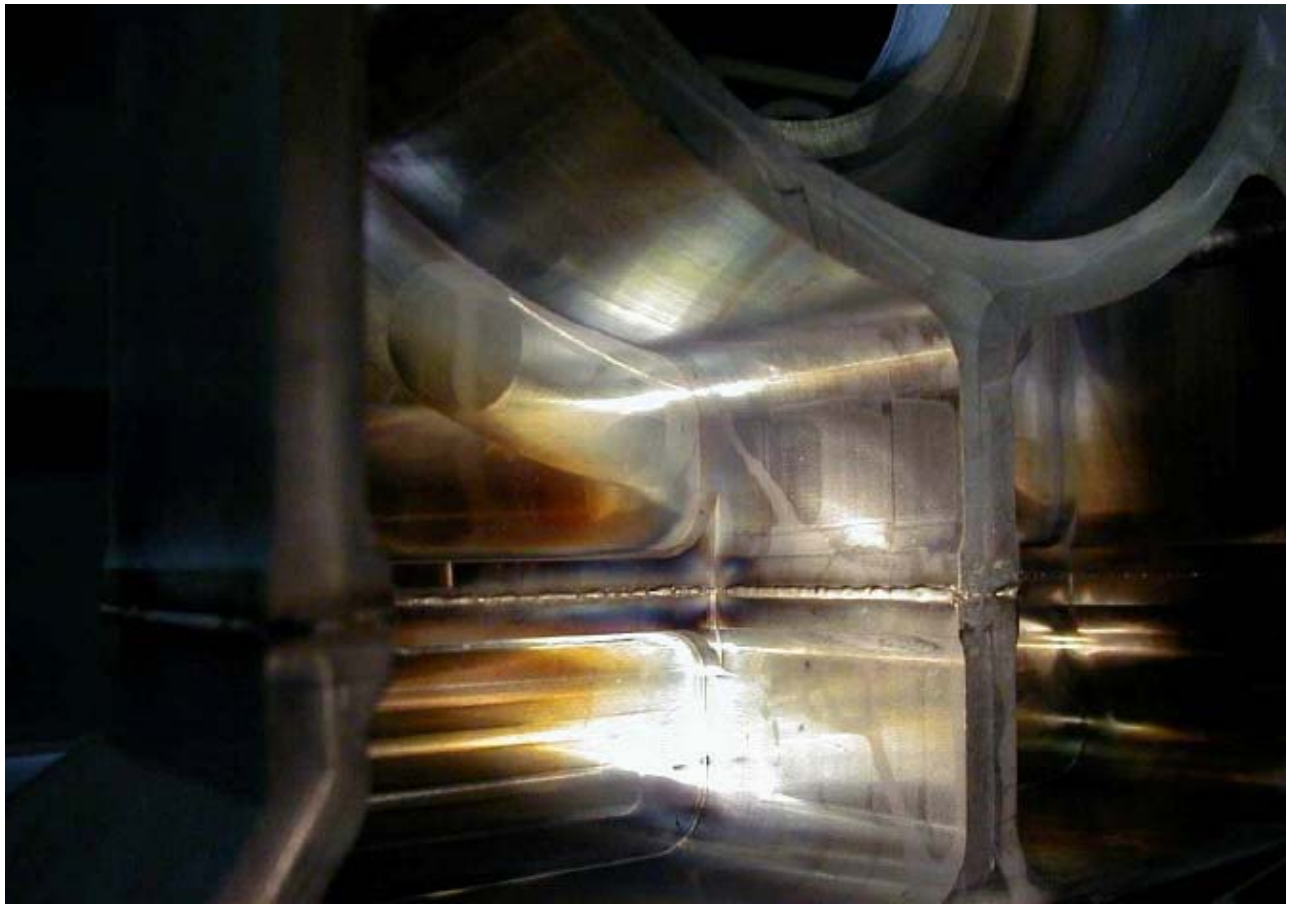
Upper Weld Section



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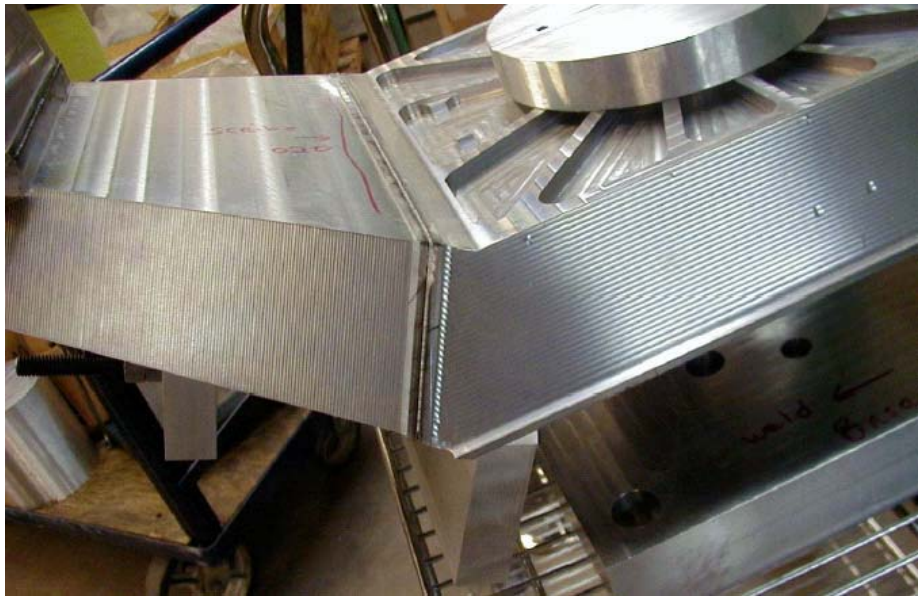
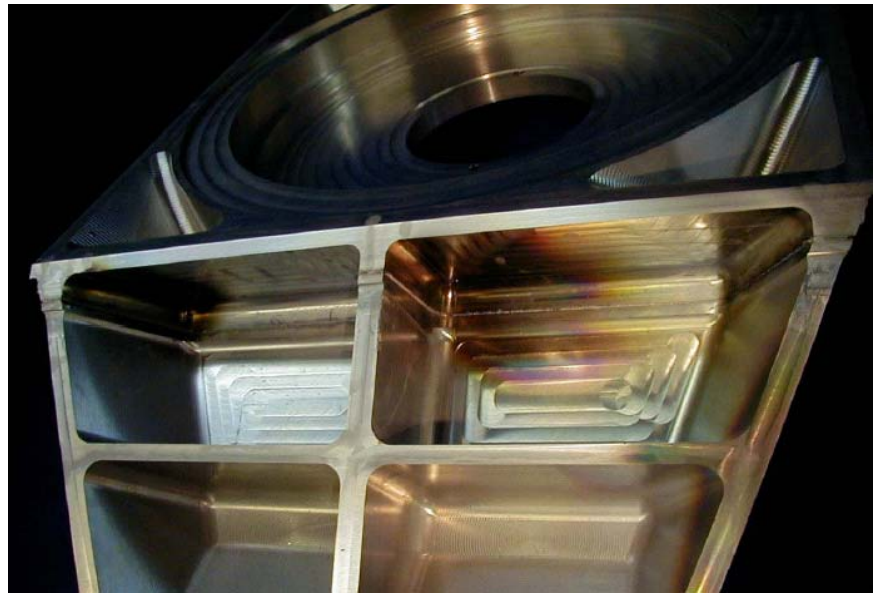
Base Weld Section





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Advanced Light-Weight On-Orbit Gimbal Structures (ALOGS)

Complete Half Yoke

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Advanced Light-Weight On-Orbit Gimbal Structures (ALOGS)

AlBeWeld™ Information

- **Electron Beam Welding is a welding process that:**
  - Utilizes a precise finely focused stream of electrons as the energy source for melting
  - Achieves heat concentrations up to 500 times that of conventional welding methods
  - Uses lower energy than conventional welding methods
  - Requires no filler alloy
  - Results in minimal distortion

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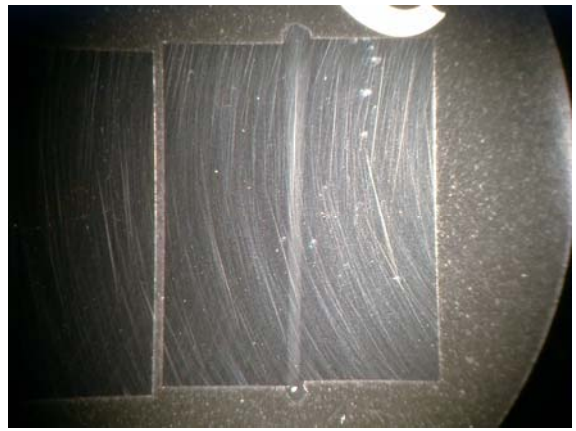
Advanced Light-Weight On-Orbit Gimbal Structures (ALOGS)

AlBeWeld™ Summary

- **Tensile properties are above AM162H specification**
- **Microstructure in weld zone finer than base metal**
- **Low Distortion process**

0.125” thick

0.350” thick



0.500” thick

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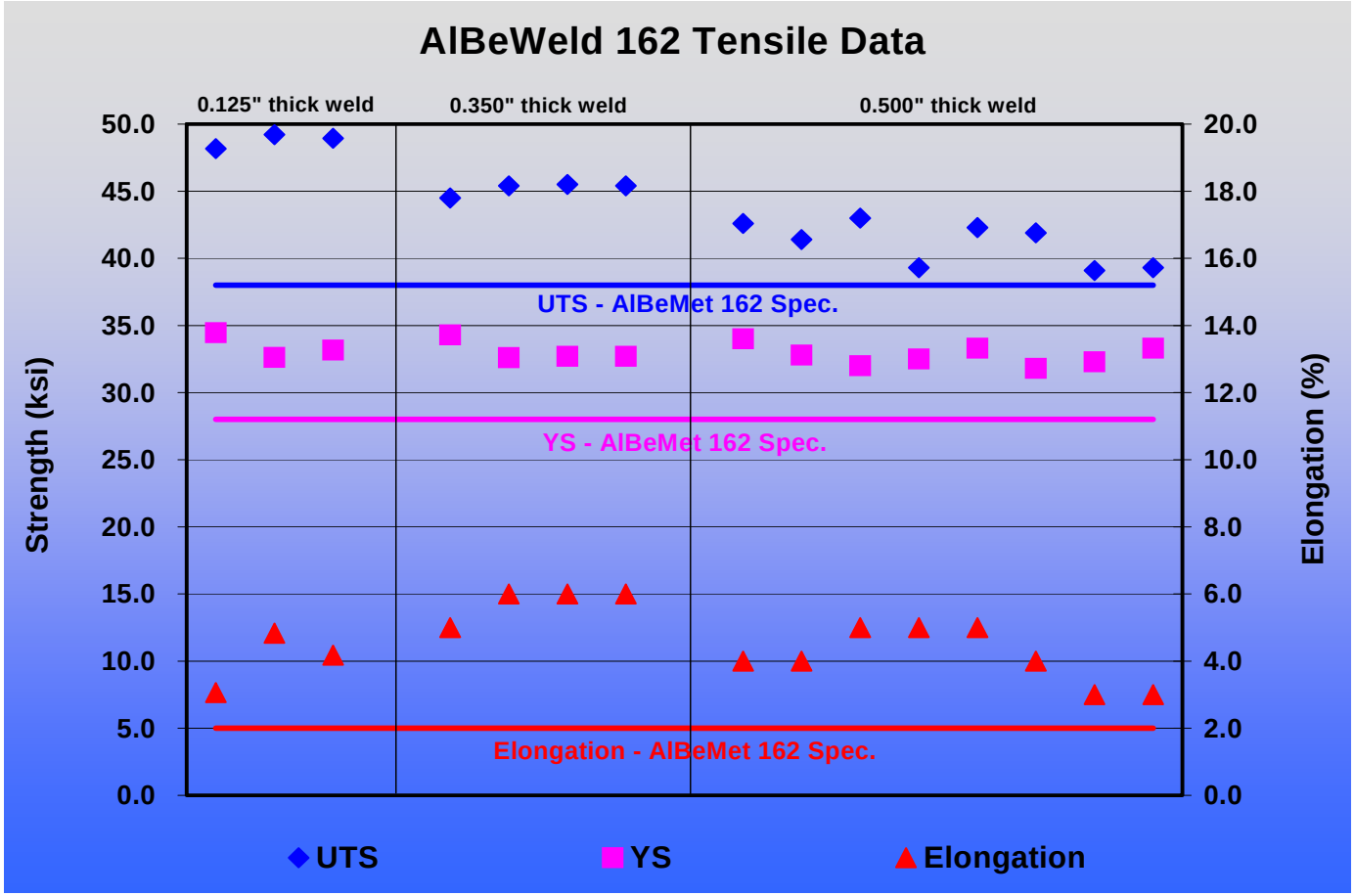
AlBeWeld™ Mechanical Properties



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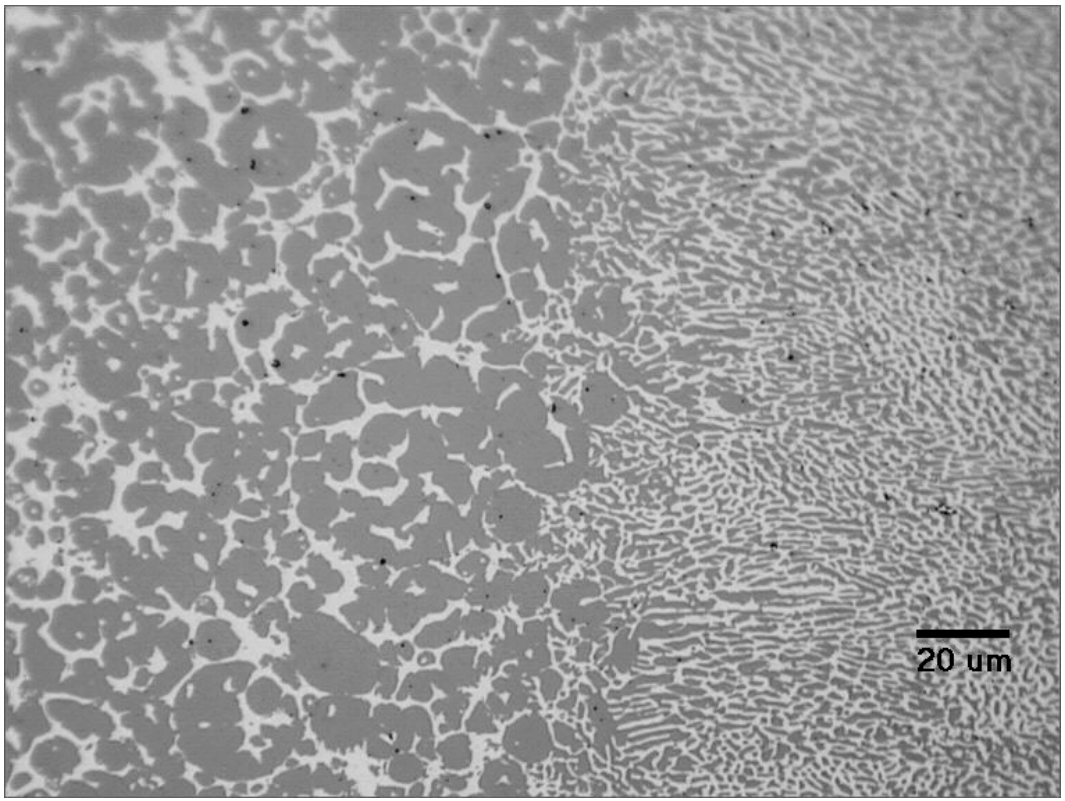
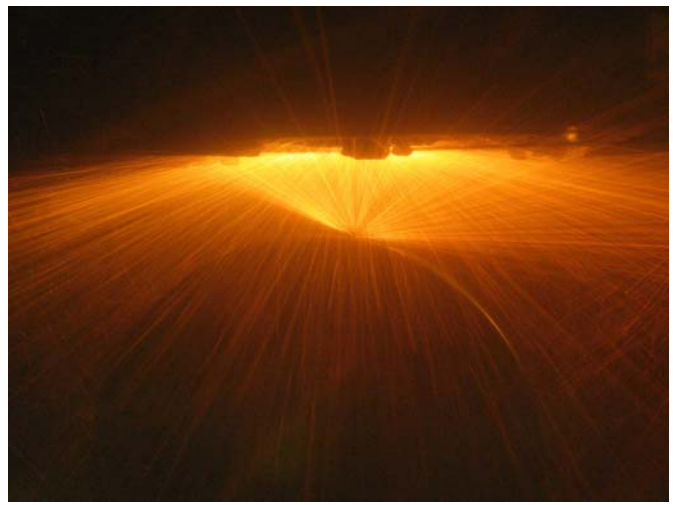
AlBeWeld™ Base Metal/Weld Zone Interface



Weld Zone Microstructure



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Advanced Light-Weight On-Orbit Gimbal Structures (ALOGS)

AlBeWeld™ Distortion

- Weld Joint Shrinkage
  - Typically less than 0.0015”
- Angular Distortion
  - Typically less than 0.12º

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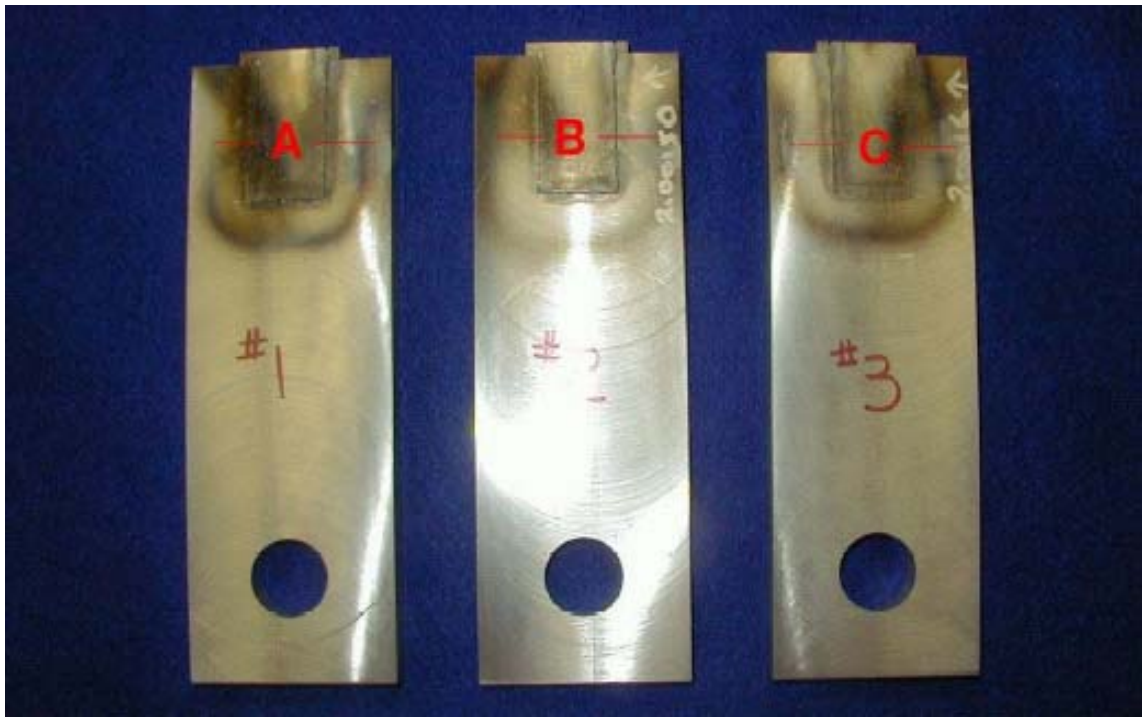
Repairability

- **Repairability coupons were designed, fabricated**
- **Coupons were tested for thermal and mechanical performance**



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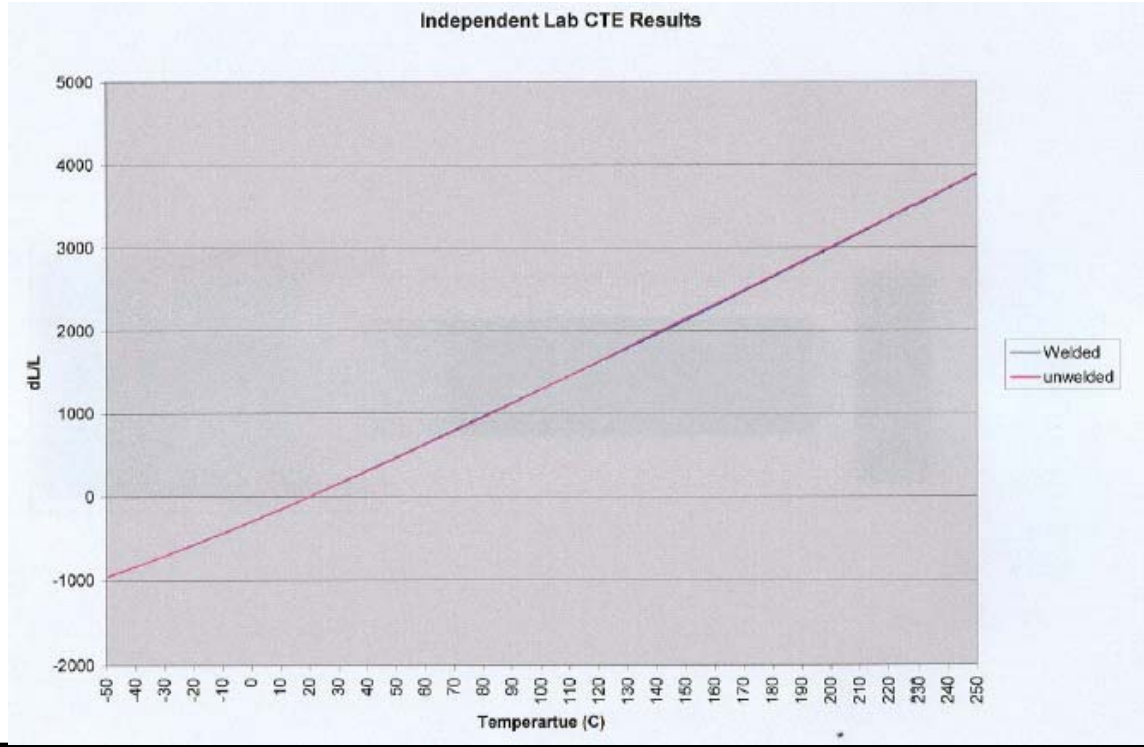
EB Welded Coupon CTE Test Results

- **No apparent difference between welded and un-welded coupons**



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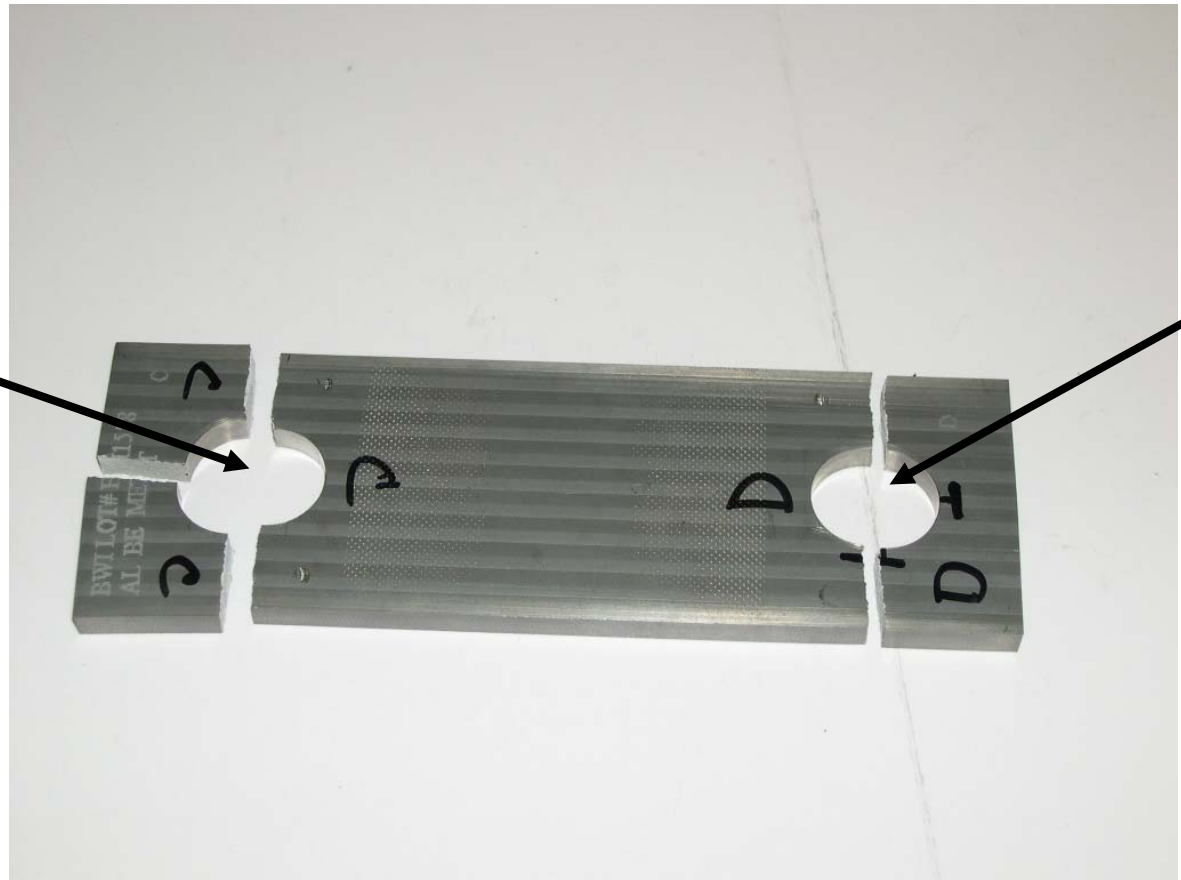
EB Welded Coupon Tensile Coupon

Hole C is welded end



Hole D is un-welded end

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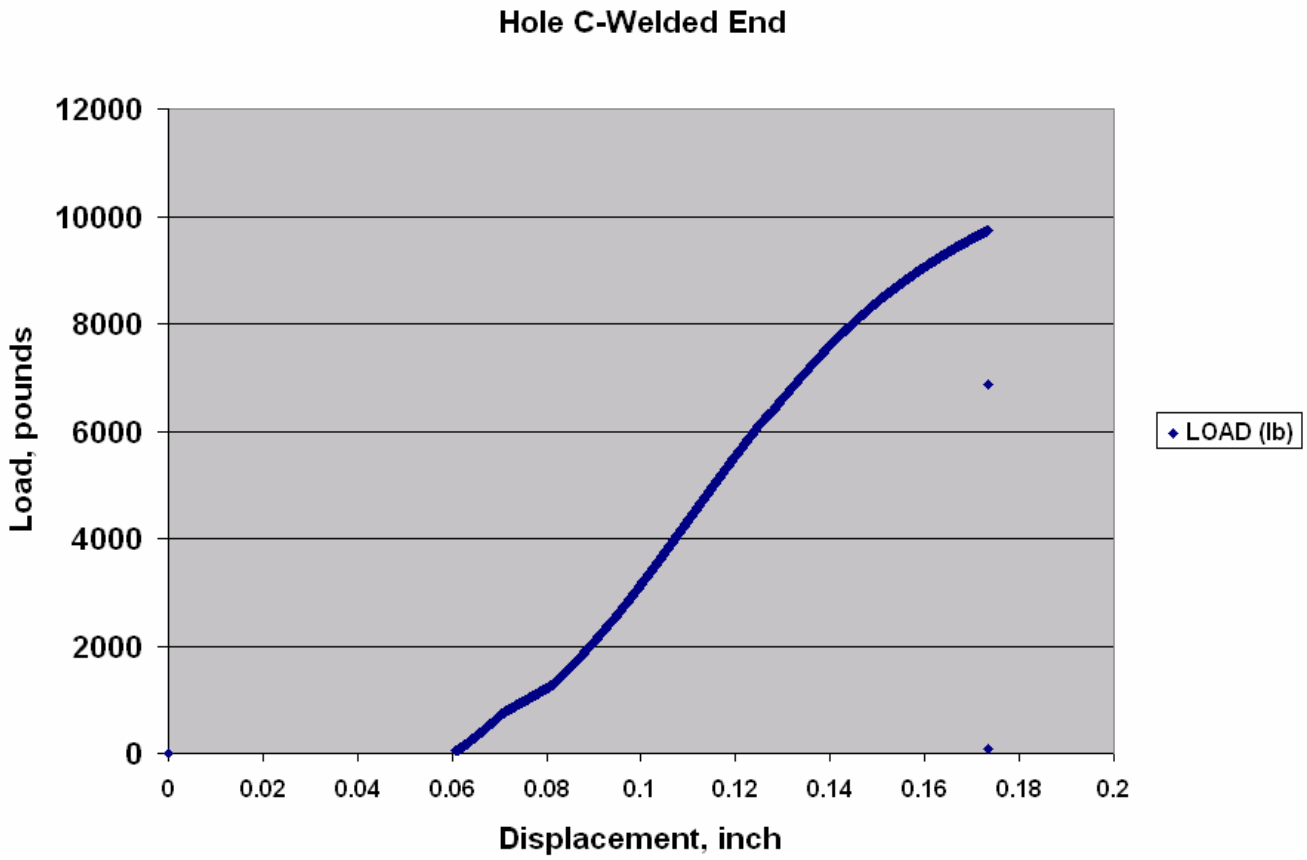
EB Welded Coupon Tensile Test Results



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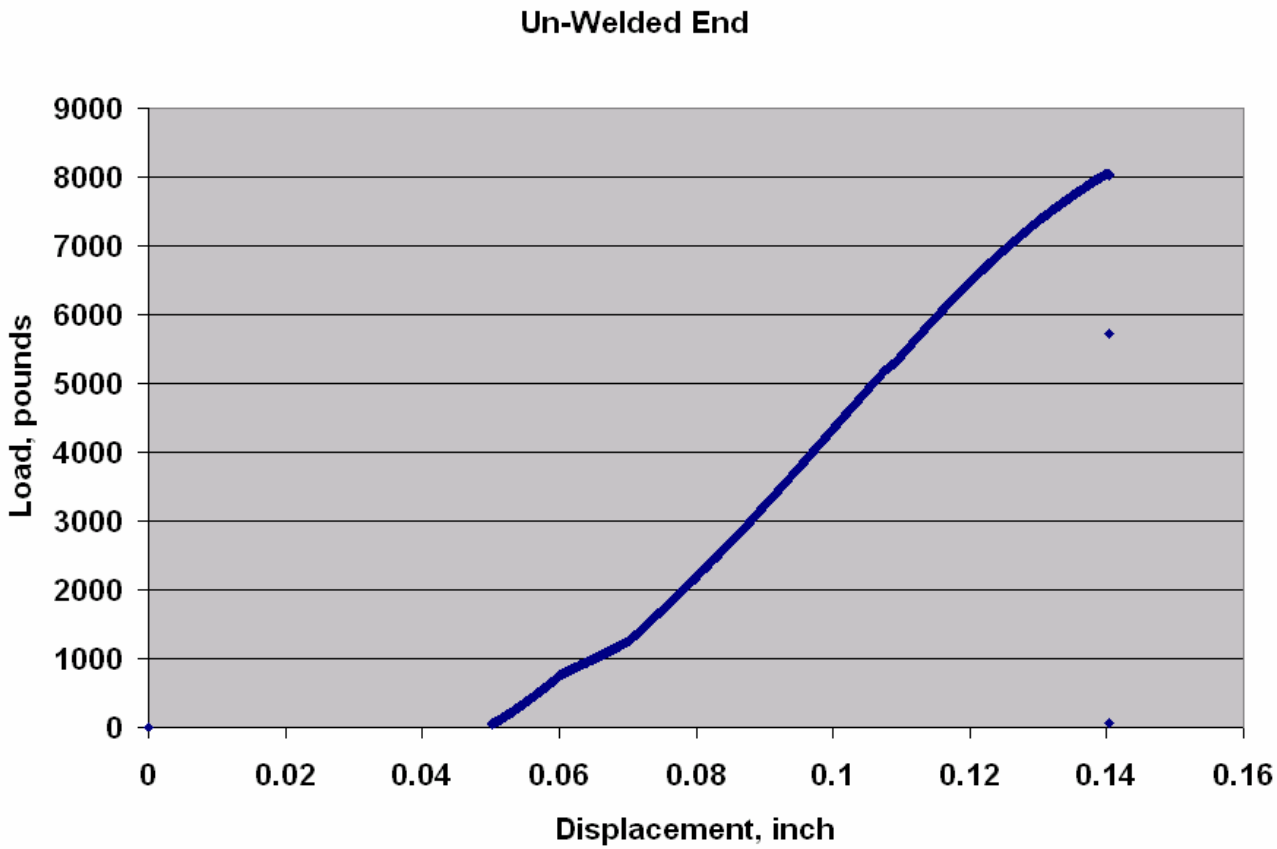

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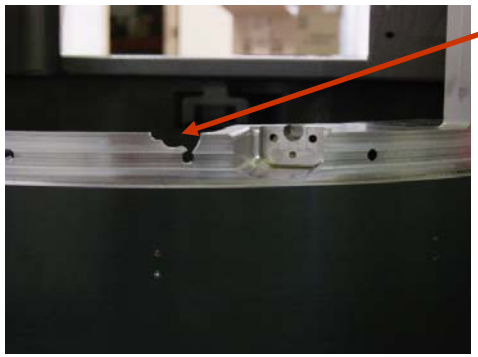
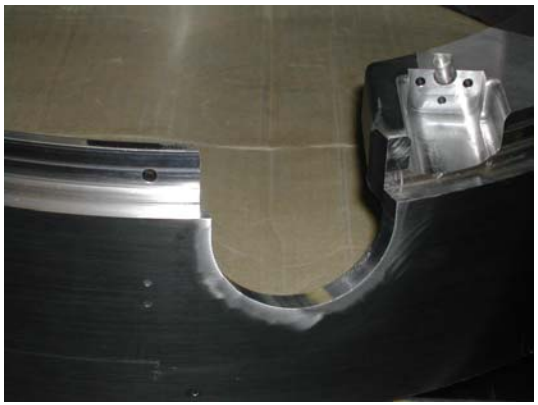
Example of Welded AlBe Assembly Being Repaired vs "Scrapped"



Original Part Damaged During Assembly



Repair Designed for Replacement Component

Part Repaired by Welding Replacement Component into Damaged Area

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Summary

- **EB Welding of AlBe Gimbal Structure was Successful**
- **It is a Cost Effective Manufacturing Process**
- **It Can Increase Manufacturing Through-put**
- **Change from Be to AlBe Will Not Compromise System Performance**
- **The New Design is 13% heavier due to property differences between Be and AlBe**

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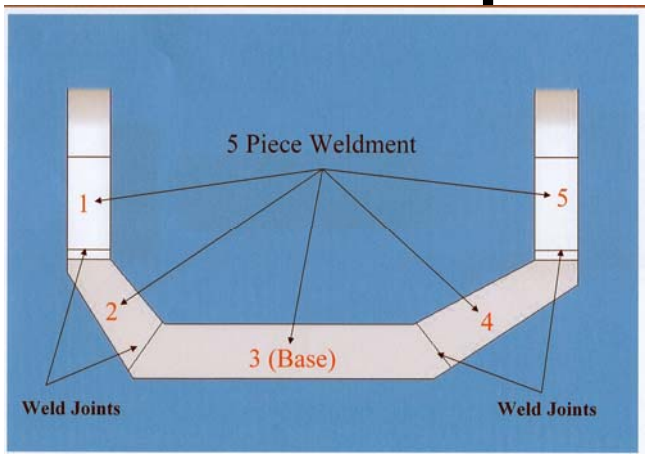
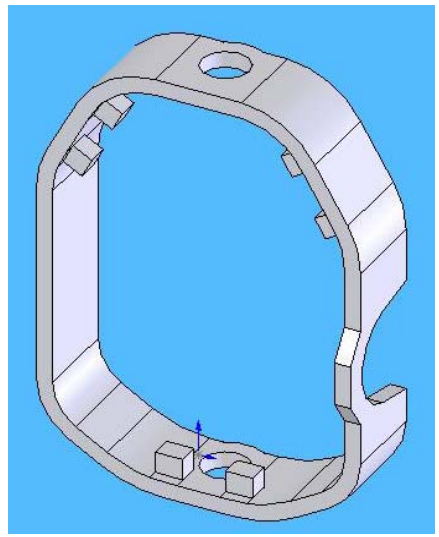
Advanced Light-Weight On-Orbit Gimbal Structures (ALOGS)

Program Objectives

- **Phase II Objectives**
  - **Manufacture five piece Gimbal**
  - **Manufacture Gimbal ring using near-net-shape technology**





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